PHENIX RUN-2016 P+P 62.4 GEV SPIN-OPTION: LONGITUDINAL-TRANSVERSE DOUBLE-SPIN ASYMMETRY A_{LT} IN FORWARD π^0 PRODUCTION

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Motivation. At RHIC, the world's only polarized proton+proton collider, one unique feature of the machine design is that each beam's spin orientation can be independently controlled at each IR. Over the last decade, p+p collisions at RHIC were made for Longitudinal-Longitudinal and Transverse-Transverse spin configurations to measure double-spin as well as single-spin asymmetries. However, no effort was ever made in Longitudinal-Transverse spin configuration, and no measurement was made on double-spin asymmetry A_{LT} in p+p collisions.

We propose to make the first A_{LT} measurement in p+p collision, in the high statistic channel of forward π^0 production, during Run-2016's $\sqrt{s}$=62.4 GeV run, and using PHENIX's MPC-EX/MPC detectors. Capable of measuring A_{LT} to sub-percent precision, PHENIX could make the discovery of a non-zero asymmetry A_{LT} in p+p collision. Such a measurement can provide a unambiguous answer to the question: inside a transversely polarized nucleon, could partons response differently to probes carrying opposite helicities ? Generally speaking, a non-zero A_{LT} asymmetry can arise from effect due to parton distributions or effects due to parton fragmentation processes. Recently, such a non-zero A_{LT} asymmetry has been reported in semi-inclusive deep-inelastic scattering ($\vec{e} + N^{\uparrow} \rightarrow e' + h + X$) experiments at JLab [1] and at HERMES. Non-zero A_{LT} asymmetries were also reported [2] in inclusive hadron production with a polarized lepton beam ($\vec{e}+N^{\uparrow} \rightarrow h + X$). Could such a non-zero A_{LT} asymmetry also exist in p+p collision, such as in $\vec{p} + p^{\uparrow} \rightarrow \pi^0 + X$ reaction ?

The prospect of the first A_{LT} measurement at RHIC inspired theoretical efforts [3] in estimating the size of $A_{LT}^{\pi^0}$. Ignoring effects from parton fragmentation completely, it was found that $A_{LT}^{\pi^0}$ is sensitive to parton distribution $\tilde{g}(x)$ (which relates to the longitudinal parton polarization in a transversely polarized nucleon), and the off-diagonal quark-gluon-quark correlation functions. Further ignoring these 3-parton correlation functions, and assuming different scenarios for $\tilde{g}(x)$, the size of $A_{LT}^{\pi^0}$ is estimated to be from sub-percent to a few-percent level [3]. Given this partial estimation of $A_{LT}^{\pi^0}$, it was pointed out that the asymmetry could end up large due to other sources [3]: 1. the hard-scattering factor in A_{LT} could be larger than expected, 2. the gluon-quark-gluon correlation functions, which are

Date: 05/14/2015.

crucial in the evolution of Qiu-Sterman function, could end up large. 3. effects from parton fragmentation, as in the case of single-spin asymmetry A_N, could be large. Therefore, a first measurement of $A_{LT}^{\pi^0}$ will not only add a new independent spin-observable to access nucleons transverse spin structure, it could also break new ground and lead to further A_{LT} measurements with forward-sPHENIX in forward jet or prompt photon channels for example, and shape new physics at the future EIC.

Expected Precision. For Run-2016 p+p 62.4 GEV runs, CAD projects a delivered luminosity of of 2.1 pb^{-1}/week. Very conservatively, we assume to record 0.67 pb^{-1} for physics analysis during two-weeks of production beam time. Assuming a similar detector performance, of the PHENIX MPC-EX/MPC detectors in Run2016, as they were in Run6, we expect a 13 fold improvement on total π^0 events collected over that of the Run6 Transverse data set (0.050 pb^{-1}). An averaged beam polarization of 0.55 is assumed. The expected precisions of $A_{LT}^{\pi^0}$ are shown in Fig. 1.

References

[1] J. Huanng *et al.* Jefferson Lab Hall A Collaboration, Phys. Rev. Lett. 108, 052001 (2012).
[2] Y. X. Zhao *et al.* Jefferson Lab Hall A Collaboration, arXiv:1502.01394 (2015).
[3] A. Metz, D. Pitonyak, A. Schaefer and J. Zhou, arXiv:1210.6555 (2015).

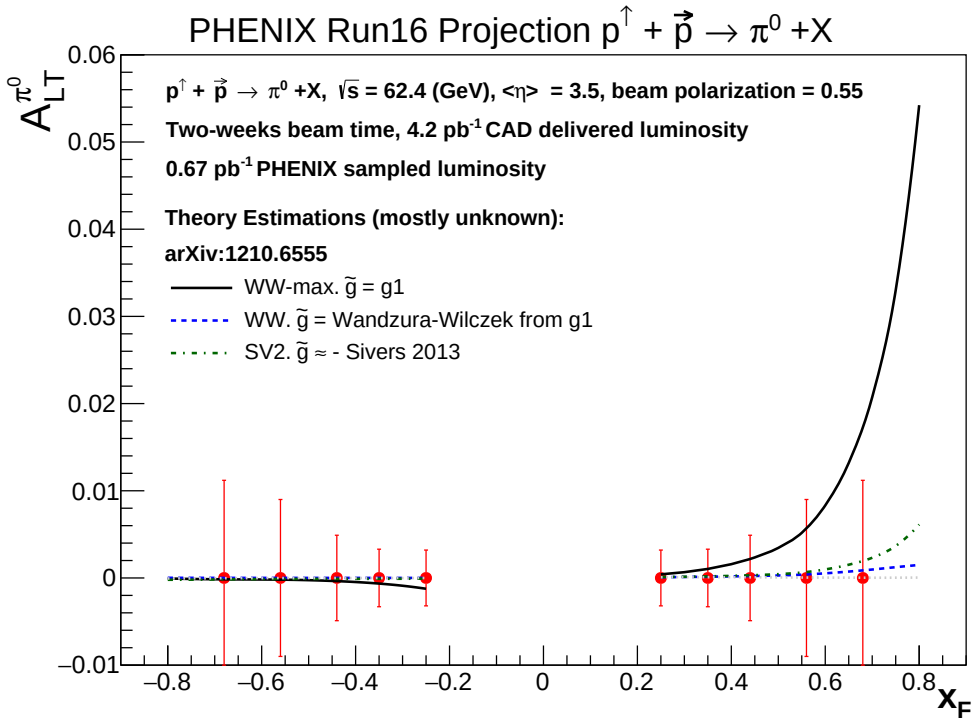

FIGURE 1. Project PHENIX Run2016 precision on $A_{LT}^{\pi^0}$ with MPC-EX/MPC detectors, for two weeks of beam time, and a conservative sampled luminosity of 0.67 pb^{-1}. Theoretical estimations ignored parton fragmentation effects and 3-parton correlation functions. Different curves correspond to different assumptions of parton distribution $\tilde{g}(x)$ (arXiv:1210.6555).